NUMERICAL APERTURE, F/No and RAYLEIGH

LIMIT REQUIREMENTS FOR NOD 110/120

MAG	F/NO FILM	F/NO SCREEN	RAYLEIGH LIMIT	NUMERICAL APERTURE FILM	NUMERICAL APERTURE SCREEN
70	3	210	.012	.167	.002380
50	3.476	173.8	.0139	.1438	.002876
41	3.943	161.663	.01577	.1268	.003092
35	4.415	154.525	.01766	.11325	.003235
30	4.969	149.07	.01988	.100623	.003354
25	5.756	143.9	.02302	.0869	.003474
24	5.957	142.968	.02383	.08393	.003497
20	6.957	139.14	.02783	.07187	.003593
15	8.981	134.715	.03592	.05567	.003711
10	13.043	130.43	.05217	.03833	.003833
9.76	13.345	130.247	.05338	.037467	.003838
7.95	16.196	128.758	.06478	.030871	.003883
5	25.285	126.425	.1011	.01977	.003954
3.7	33.911	125.4707	.1356	.01474	.003984
3.3	37.956	125.2548	.1518	.01317	.003991
3.16	39.597	125.1265	.1584	.012627	.003995
3	41.635	124.905	.1665	.01201	.004003

Rayleigh Limit (in μ)= 4* F/No

$N.A. = \frac{.5}{F/No}$

Declass Review by NGA.

RADC-TR-67-533

AN INITIAL EVALUATION OF THE [redacted] NOD-100 VIEWER [redacted]

STAT

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TECHNICAL REPORT NO. RADC-TR-67-533
September 1967

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Rome Air Development Center
Air Force Systems Command
Griffiss Air Force Base, New York

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AN INITIAL EVALUATION OF THE [redacted] NOD-100 VIEWER STAT

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AFLC, GAFB, N.Y., 6 Nov 67-265

FOREWORD

The test and evaluation, which this report documents, was undertaken to determine the specific capabilities of the [redacted] Model 100 rear projection viewer. As such, this was basically an engineering test and evaluation, and the data obtained does not indicate the operational utility of the device. The efforts discussed were accomplished under Project 698DB, Task 01. STAT

The item reported on herein was not specifically developed or manufactured to meet Government specifications, to withstand the tests to which it was subjected, or to operate as applied during this evaluation. Any failure to meet the objectives of this evaluation is no reflection on the item discussed herein or on the manufacturer.

The data gathered during the tests was, except where noted in the resolution tests, generally collected by [redacted] of the 544 ARTW Research Center (SAC). His participation is noted with appreciation. The tests were observed by [redacted] of the Research Center and [redacted] of the Ogden Air Materiel Area, Hill AFB, Utah. STAT STAT STAT

The assistance and cooperation received from [redacted] personnel during the test and evaluation period was outstanding. In particular, [redacted] engineer in charge of the development of the model 100, [redacted] as well as [redacted] in general, are to be highly commended for providing this device at no cost to the Government for the four-day period which was utilized for the examination. STAT STAT STAT

This test and evaluation is a portion of a continuing RADC program to improve equipment and techniques in the area of ground handling of aerial reconnaissance data. The program takes the form of engineering support to reconnaissance data utilization facilities as well as the development of new equipment and techniques. Comments on this report, and on subjects related to aerial reconnaissance ground data handling equipemnt and techniques, are invited and should be forwarded to: RADC (EMIRA), Griffiss AFB, New York 13440.

This technical report has been reviewed by the Foreign Disclosure Policy Office (EMLI). It is not releasable to the Clearinghouse for Federal Scientific and Technical Information because information in this report is embargoed under the Department of State ITIARs. This report may be released to foreign governments by departments or agencies of the U.S. Government subject to approval of RADC (EMLI) or higher authority within the Air Force. Private individuals or firms require a Department of State export license.

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ABSTRACT

The [redacted] Model 100 rear projection viewer was tested to determine its specific capabilities. The tests accomplished included AWAR resolution, screen brightness, distortion, magnification, field of view, film transport speeds, and ease of operation. The results indicate that this viewer is comparable to similar viewers presently in use, but it has a significant additional capability of continuous zoom magnification from 3.5X to 82X.

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AN INITIAL EVALUATION OF THE [redacted] NOD-100 VIEWER

A. Introduction

1. A test and initial evaluation was conducted on the [redacted] Model 100 Viewer on 22, 23, and 24 May 1967. The purpose of the test was to determine the technical characteristics of the viewer and to obtain an initial indication of the operational utility of the unit.

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2. The Model 100 Viewer was made available to Air Force personnel by [redacted] and the tests were conducted by Rome Air Development Center (RADC) and Strategic Air Command (SAC) personnel. Specifically, the SAC representatives were from the Research Center of the 544 Aerospace Reconnaissance Technical Wing, Offutt AFB, Nebraska, and the RADC representative was from the Reconnaissance Engineering Section, Reconnaissance and Intelligence Data Handling Branch of RADC. In addition, a representative of the Ogden Air Materiel Area (OOAMA), Air Force Logistics Command, was on hand as an observer.

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B. Description of the Test Item: The [redacted] NOD [redacted] Optical Device)-100 rear projection screening viewer (also called the Model 100) is a piece of equipment which is approximately 85" long, 78"

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high, and 36" wide (see Figure 1). It has a 30" square Polacoat LS-60 screen on which the images of 70mm to 9.5" aerial film (spool size up to 10 1/2" diameter) are viewed at magnifications from 3.3x to 82x. The magnification is continuously variable throughout the entire range. The Model 100 weighs approximately 1560 pounds, including the blower for cooling air which is an external component. This viewer requires approximately 3.5 KVA of single phase, 115 volts, 60 Hertz power.

a. The film drive is located just inside the front door which is hinged on the left side. The entire front, including the screen and control panel, swings outward following release of two latches. The film drive is servo-controlled, and has been designed for smooth, non-destructive transport at speeds up to 50 inches per second (250 feet per minute). Image rotation of $\pm$ 180° is provided by rotating the entire film drive system.

b. The controls are conveniently located for the operator, no matter where he may be located (within about 10 feet of the screen). The power on/off, film rewind, and end-of-roll override pushbuttons are located on the lower left of the vertical panel. Just above these is a film footage counter. A meter to indicate the voltage at the lamp (indicating light intensity), and a meter showing the magnification, are in the center

Figure 1: The
NOD-100 Rear Projection Viewer

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of this panel. The operator controls are mounted on a remote box which is attached to the viewer by a cable approximately 8 feet long. This box contains the film drive joystick, image rotation control, slew/scan film speed pushbutton, focus control, brightness control, and the magnification control.

c. Access to the interior optical and electronic components of the viewer is through two removable panels on each side of the cabinet. These panels are each attached to the unit by eight 1/4-turn Dzus-type fasteners. The basic structure of the Model 100 consists of the metal braces and other structural components necessary to minimize vibrational degradation of the images at high magnification.

C. <u>Test Plan:</u> The test plan and procedures (See Appendix
STAT A) were prepared by [redacted] and reviewed by both SAC and RADC personnel. Some minor changes were made to make the test more representative and/or to better illustrate the capabilities of the viewer. In general, the tests accomplished were similar to tests made on the same type of equipment previously purchased by SAC and RADC.

D. <u>Testing</u>

1. Testing was generally accomplished in accordance with the procedures outlined in the test plan. The following paragraphs provide additional information on

the methods of performing the tests.

2. Resolution:

a. The resolution test was conducted by both SAC and RADC, and with three different test targets. Rather than using a series of test targets imaged on the test film in an Area Weighted Average Resolution (AWAR) configuration, one standard USAF 1951 test target (consisting of individual resolution blocks) was used in each case. The SAC readings were made with a target having white (clear) lines on a black background (high contrast), while the RADC readings were made with a target having black lines on a clear background. The measured resolution limit of both of these targets was 228 lines per millimeter (lines/mm). A third test was accomplished using a high contrast target with a measured resolving capability of 1000 lines/mm. This target had 14 line pairs in each resolution block, 11 blocks per group, and three groups. The standard targets were spliced into a 5" roll of film; while the 1000 lines/mm target was placed into the film gate by itself, since it was on glass.

b. The target was placed in the nine test positions by moving the film platen. The RADC tests were made by rotating the target so that the target lines were radial, or tangential to a radial line, to the center of the screen. The optical system was then refocused for the best definition of the radial target and the resolution read. The SAC tests, on the other hand, were made with the target lines parallel to the edges of the viewing screen at all positions; and the optical system was focused for best definition. The 1000 line target was only used at the center of the screen.

c. A target element was defined as being resolved when a fine line could be seen as separating the lines in the target. For the SAC readings, at least one line pair (of the two in the Standard 1951 target blocks) was discernible before a particular block was chosen as the resolution limit. For the RADC readings, all the line pairs were discernible before a block was chosen. Generally, this made no difference in the blocks chosen between the SAC and RADC readings.

3. Screen Brightness: The screen brightness test was conducted at a lamp voltage of 120 VAC. This is considered to be the maximum voltage the operator would apply to the bulb. No minimum readings were taken since no light reaches the screen at minimum brightness. The equipment used for this test was furnished by [redacted] STAT
It consisted of a Spectra Brightness Meter and a 100 foot-lambert calibrated light that is used to check the accuracy of the meter. Using the calibration light, the meter was corrected at 100 foot-lamberts. The readings

were then taken by positioning the meter normal to the screen at the points described in Figure 2 (Page 7) of the Test Plan.

4. Image Rotation: The image rotation tests were accomplished in accordance with the procedures outlined. It was found that the displacement of the optical axis during rotation could not be accurately measured. In order to do a test of that type, the exact optical axis position would need to be measured and marked on the screen. The image could then be rotated 180° and the displacement of an image originally positioned on the optical axis could be measured. However, for this test series, no attempt was made to precisely locate the optical axis. The result, therefore, is only an approximation.

5. Focus: The initial focus test was accomplished in accordance with the procedure outlined in Appendix A. However, by visually observing the clarity of the test target, the results become quite subjective. Therefore, a second test was run by measuring the resolution at the center of the screen at each designated magnification. (Although resolution measurement is subjective in itself, it is not considered to embody the problems associated with visual observation.)

6. Distortion: The distortion test was first run in

accordance with the test plan. The scale was placed in the center vertical, right horizontal, and upper right (45° angle) positions and screen length measured. The screen length was then compared with the actual length of the target (taking into account the magnification), and the percent distortion calculated. The test was then run with a grid consisting of 1 mm squares on a 70mm by 100mm film chip, which was spliced into a roll of 70mm film and observed on the screen. A total of eight readings were made, with one reading near each corner of the screen, and one reading midway between the center and each corner. This test was only made at about 15X magnification, at which the test target filled the screen.

7. Field of View: The amount of vignetting was measured at 3.3X by determining the distance from the edge of dark area to the corner of the screen. This was accomplished with a scale held radial to the center of the screen. The second field of view test was adversely affected by the vignetting. The entire 9 1/2" of the film could not be seen on the screen at the lowest magnification. An additional test was made with a field of view test target on a 70mm by 100 film chip, and measurements were made at about 13X, 20X, 40X, 50X, 60X, 70X, and 82X.

8. <u>Film Transport System:</u> In addition to the tests noted in the plan, a scratch test was run by loading a new roll of 9 1/2" aerial film (about 200 feet long) and running it back and forth. A section of film 50 feet long was selected for the slew test. This section was slewed 30 times in each direction with a sudden change in direction at each end of the test area. Another test section of 6 feet of film was selected for the scan test. This section was scanned 10 times in each direction at maximum scan speed and then examined for damage.

9. <u>Alternate Heat Test:</u> A standard base, 5" roll of film was loaded on the machine. An area of 2.0 density (density was determined by [redacted] personnel) STAT was focused on the screen at 70X magnification and 120 VAC lamp voltage. The machine was maintained at these settings. At the end of 2 hours, the film was removed from the machine and examined for possible heat damage.

E. <u>Results:</u> A summary of the results is given in Appendix B. The collected data is on file at RADC/EMIRA, Griffiss AFB, New York 13440.

F. <u>Discussion of Results</u>

1. Resolution: The resolution tests show that the Model 100 has a high contrast resolving capability which is on a par with other rear projection viewers used by

Air Force reconnaissance ground data handling organizations. (See Figures 2, 3, and 4).

a. The Area Weighted Average Resolution (AWAR) was lowest (about 1.7 lines/mm/power) at the lowest magnification, and highest (about 3 lines/mm/power) at intermediate magnifications. Since resolution measurements were not made at a large number of magnifications, the curves only illustrate the general trend of the resolution as it changes with magnification. Since the RADC readings were taken with a chart having black target lines on a clear background, they show a generally lower resolution than the SAC readings which were taken with a chart having clear lines and an opaque background. A target was defined as resolved when a fine line of background could be seen between the lines (bars) of the test target. The same definition for the resolution limit was used for both the SAC and RADC readings. The lower RADC readings were expected because of the additional light scattering using the black-on-clear target.

b. The on-axis resolution (Figure 3) tended to be much greater than the AWAR. (The resolution measured here was actually at the center of the screen, but not necessarily on-axis.) The same general trend of lower RADC readings was exhibited. The on-axis readings listed are the same as used in the calculation of the AWAR.

STAT The [redacted] data is also included in Figure 3: their readings were taken at some previous time. The type of chart

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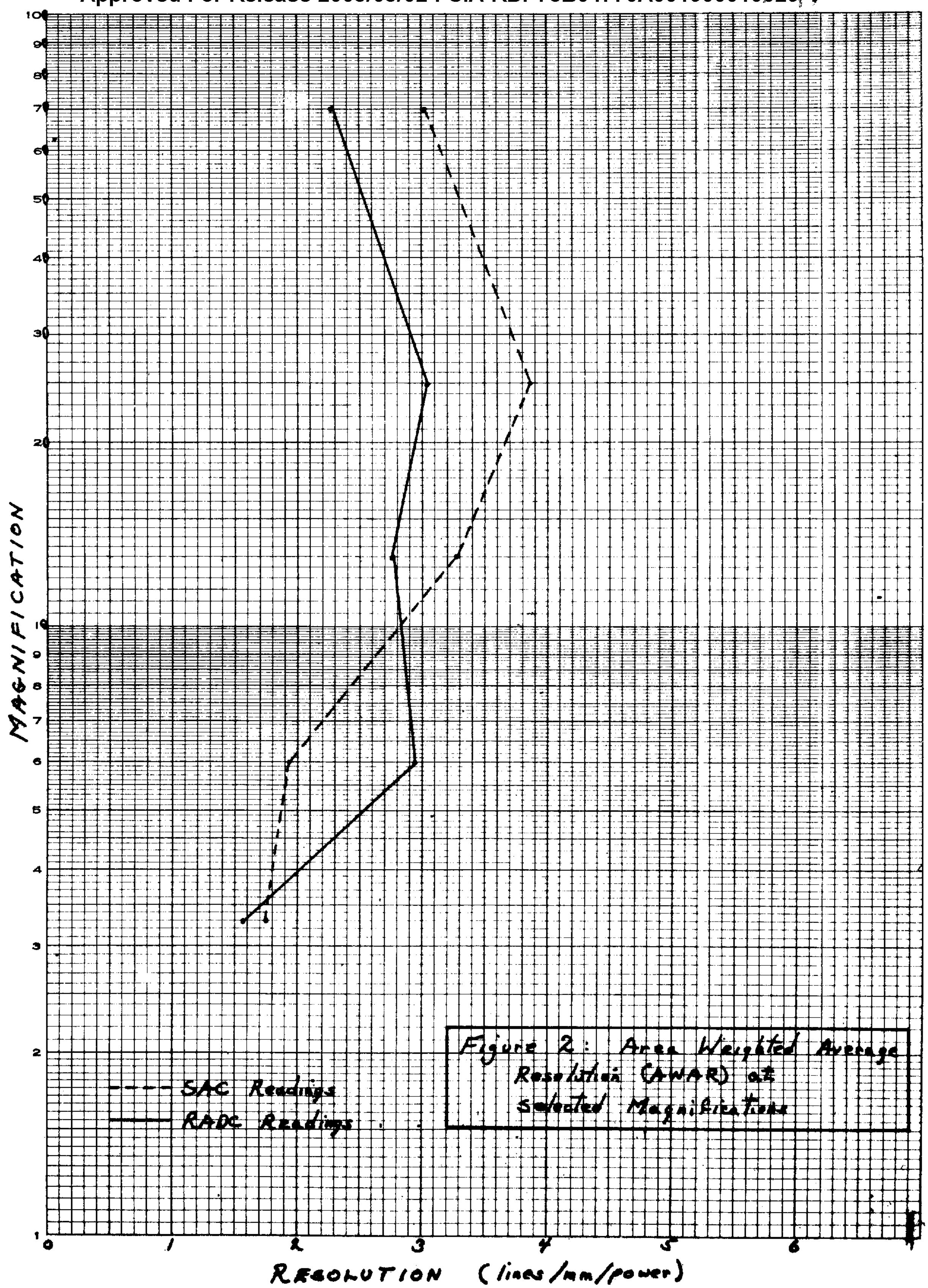

Figure 2: Area Weighted Average Resolution (AWAR) at selected Magnifications

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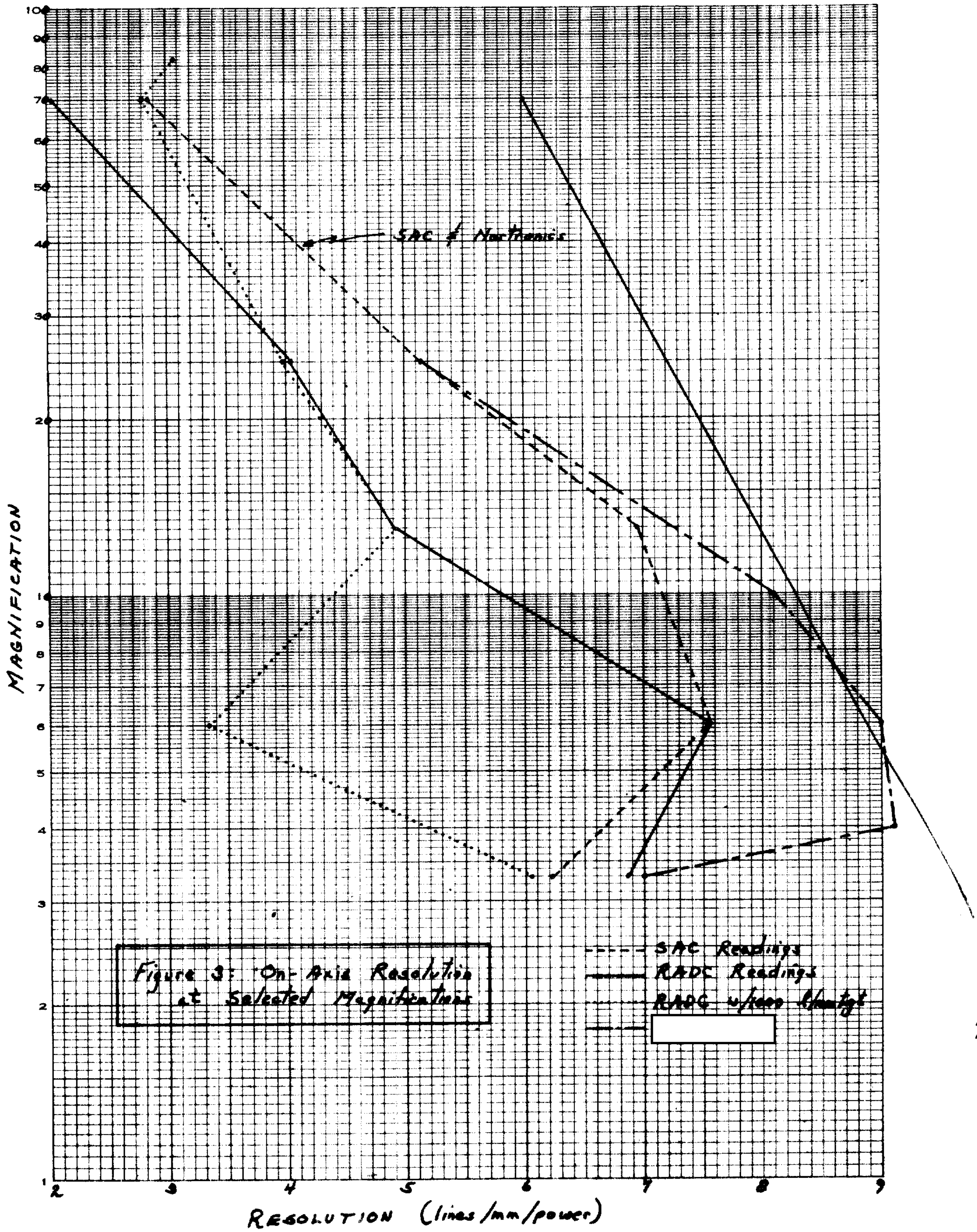

Figure 3: On-Axis Resolution at Selected Magnifications

25X1

used is not known; however the [redacted] reading is somewhat STAT
higher at 6x than either SAC or RADC. An additional on-axis measurement was made with a test target having a measured resolving power of 1000 lines per millimeter. At the low magnifications (except for 6x), the readings with this target were approximately the same as with the 228 lines/mm target. At the high magnifications, the measured resolution was greater than with the 228 lines/mm target. This difference is attributed to the quality of the target, since it was not being used near its resolution limit. At 6x with the 1000 lines/mm target, it was noted that the block indicating a resolution of 8.56 lines/mm/power could be resolved as well as the 3.33 lines/mm/power block. The 3.33 reading is indicated in Figure 3, however the true reading is probably somewhere between 8.56 and 3.33 lines/mm. This "phenomenon" is explained by the theory for transfer functions, and exemplifies one of the problems inherent in resolution measurements.

c. The average edge resolution was obtained by dividing the sum of the edge resolution readings by the number of readings. Contrary to the trend of the on-axis resolution, as the magnification is increased, the average edge resolution improved. In fact, at the highest magnifications the average edge resolution is better than the on-axis resolution. In operational usage, therefore, it would be more advantageous to view images that are off the optical

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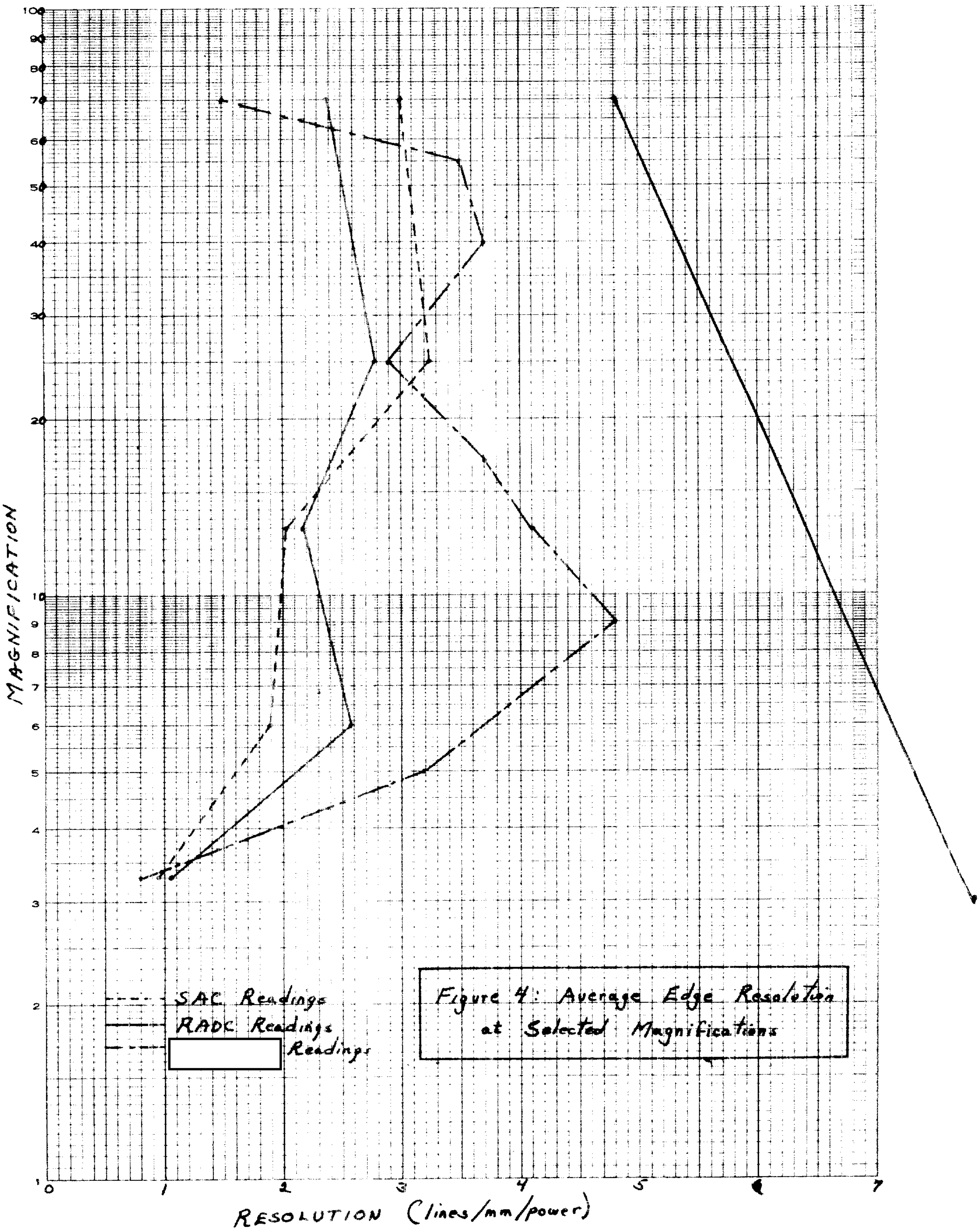

Figure 4: Average Edge Resolution at Selected Magnifications

25X1

axis as they will be somewhat more clear. The [redacted] STAT edge resolution readings were again higher than either the SAC or RADC readings. Since the determination of the resolution limit is dependent on a subjective evaluation, the differences are attributed to differences in the resolution limit definitions.

2. Screen Brightness:

a. The screen brightness (see Figure 5) was much lower than that required for optimum viewing during normal operation. A screen brightness of several hundred foot-lamberts is needed in most operational applications. The reduction in brightness, from the lowest magnification to the highest was to about 18% of the brightness at the low magnification. If the brightness were 400 foot-lamberts at 3.3x, then this would be reduced to 72 foot-lamberts at 70x assuming that the source characteristics did not change. Such a brightness would be more appropriate for operational usage. The average edge brightness shows a sharp fall-off at the lowest magnification. This is due to the fact that two of the edge brightness readings at 3.3X were within the vignetted area of the screen. The actual edge brightness at 3.3X would follow the curve for the center brightness and be about 72 foot-lamberts if the readings are taken within the illuminated area.

b. In addition to the lack of sufficient illumination, vignetting was also a problem. At 3.3x, it was found that the vignetting reduced the field of view by 6" (measured

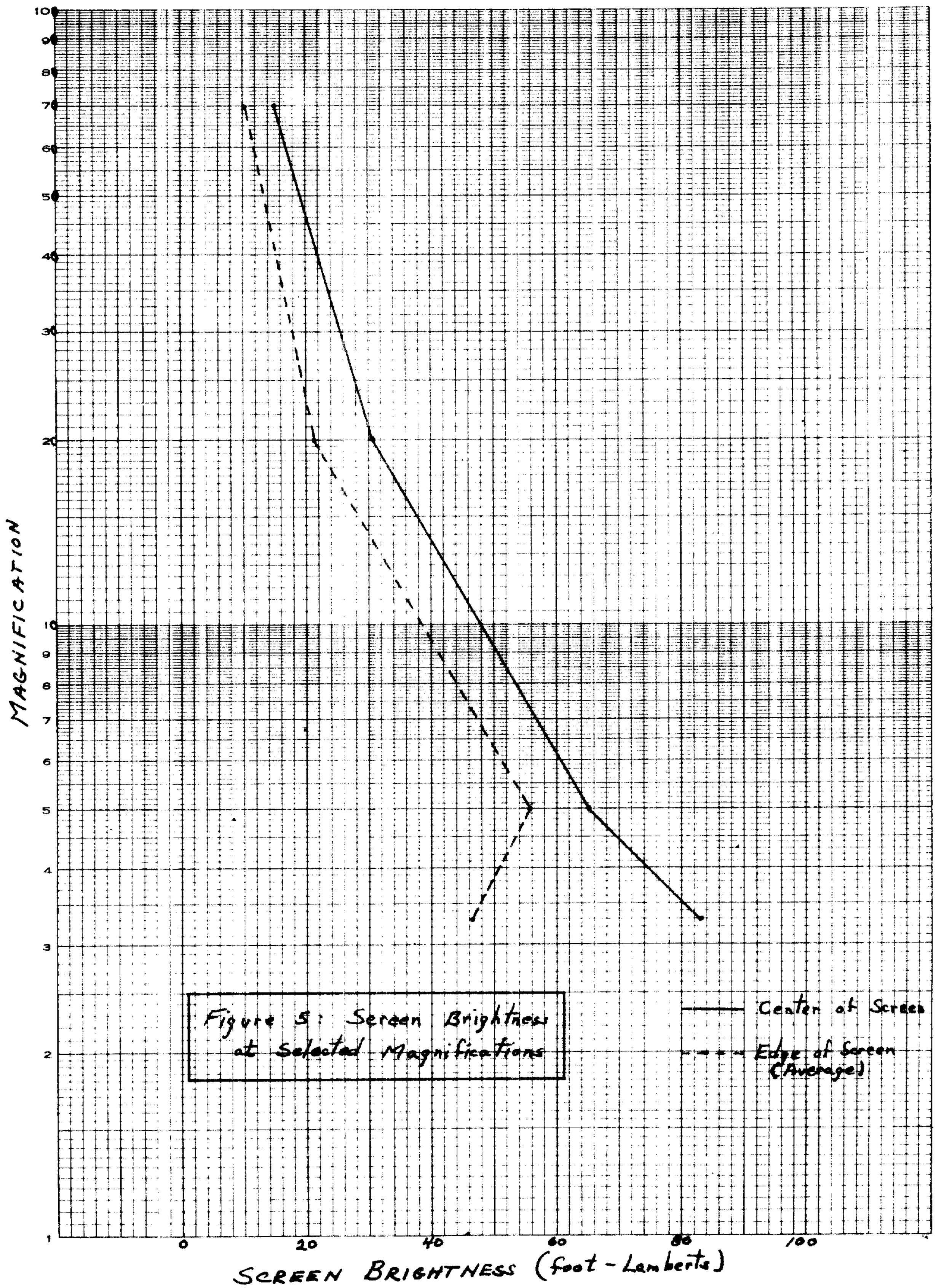
Figure 5: Screen Brightness at Selected Magnifications
Center of Screen
Edge of Screen (Average)
MAGNIFICATION
SCREEN BRIGHTNESS (foot-Lamberts)
1
2
3
4
5
6
7
8
9
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100

radially toward the center of the screen) at the top corners, 5" at the bottom left corner, and 4" at the bottom right corner. As the magnification was increased, the amount of vignetting decreased until the entire screen became illuminated at 13X. The purpose of having a magnification of approximately 3.3x is to be able to view the entire format of a 9" frame of photography on the 30" x 30" screen (9" x 3.3 = 29.7"). However, the vignetting at 3.3x reduces the field of view to a circle with a diameter (on the film) of only 9.5": this allows about 86% of a 9" x 9" frame to be viewed at once, and defeats the purpose of the lowest magnification.

c. A problem was also found, at the lowest magnification, in the colored (Newton) rings projected on the screen. These rings occurred from the edge of the illuminated area to approximately 8-1/2" from the center of the screen. As the magnification is increased, the colored rings move outward from the center of the screen until they are no longer within the field of view at about 9x. It was noted that some Newton rings could be obtained at high magnification. However, these rings would disappear when the film drive system was actuated, indicating that they were formed by the glass platen resting on the film.

3. Magnification Range:

a. The measured magnification range was from

3.5x to 82x, indicating a zoom ratio of about 23.5:1. The main advantage of having a large-ratio zoom capability is the ability to change the magnification of a particular target until the precise size desired by the interpreter is obtained. Discrete magnifications, on the other hand, may result in a situation where one magnification is too low for the job to be done while the next larger magnification exceeds the resolving capability of the film. The problem with using zoom optics in the past has been their poor resolution as compared to the use of separate lenses for discrete magnification steps. However, the Model 100 exhibits reasonably good resolution throughout the entire 23.5:1 zoom range. (Although it was only checked at selected magnifications, the results probably are indicative of the full range).

b. The time to change the magnification from 3.5x to 82x was found to be three seconds at the highest speed and 18 seconds at the lowest practical speed. The ratio of the speed range is therefore approximately 6:1, which appears to be satisfactory.

c. During the magnification range tests, it was noted that an image positioned at the center of the screen at 3.5x moved to a position 70mm left and 116mm above the center of the screen at 82x. This change in position was not considered objectionable since a target in the center of the screen would remain on the screen at all magnifications.

4. Image Rotation:

a. The rotation speed was determined to be approximately 12 degrees per second. This is considered to be adequate. However, it was noted that the null position of this servo-controlled device was too large for precise image positioning. The image rotation ring on the joystick could be moved slightly with no effect on the displayed image, yet another slight movement would result in too much rotation. This problem is considered to be a deficiency: it would be particularly unsatisfactory if the crosshairs on the center of the screen were used for mensuration and it was necessary to rotate the image a discrete amount.

b. The check for optical axis displacement showed approximately one millimeter movement at the film plane. Since the crosshair on the screen did not necessarily indicate the optical axis, and since no attempt was made to precisely locate the optical axis, the results merely indicate that the optical axis was not at the center of the cross-hairs. The amount of deviation from the cross-hairs during rotation is not considered objectionable.

5. Focus: The Model 100 was generally in focus throughout the magnification range when it was focused for best definition at 70x. An additional focus test was made by reading a test target in the center of the screen at several magnifications with (228 lines/mm

target) and without (1000 lines/mm target) refocusing (see Figure 6). The resolution was consistently poorer by one resolution step at most magnifications, even though a greater resolution was read at 70x during the non-refocusing check. Although the resolution is less when the unit is not refocused, it appears as if the amount of resolution loss is not significant enough to cause problems. In addition, refocusing for the best definition at any selected magnification could be easily made by the operator. (Note that the curve for non-refocusing reflects the transfer function problem previously mentioned.)

6. Distortion:

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a. The [redacted] distortion test method showed no greater than 4.5% distortion. However, this method only showed the total amount of displacement of a point from its true position in relation to the center of the screen. The alternate test, on the other hand, showed distortion to be as much as 10%. This method compared the size of a short line segment near the edge of the screen to its true size.

b. The third distortion test was made with a grid consisting of one-millimeter squares, and it was only done at the point where the target filled the screen (at 15x the target was distorted enough that portions of it were at the edge of the screen while other portions

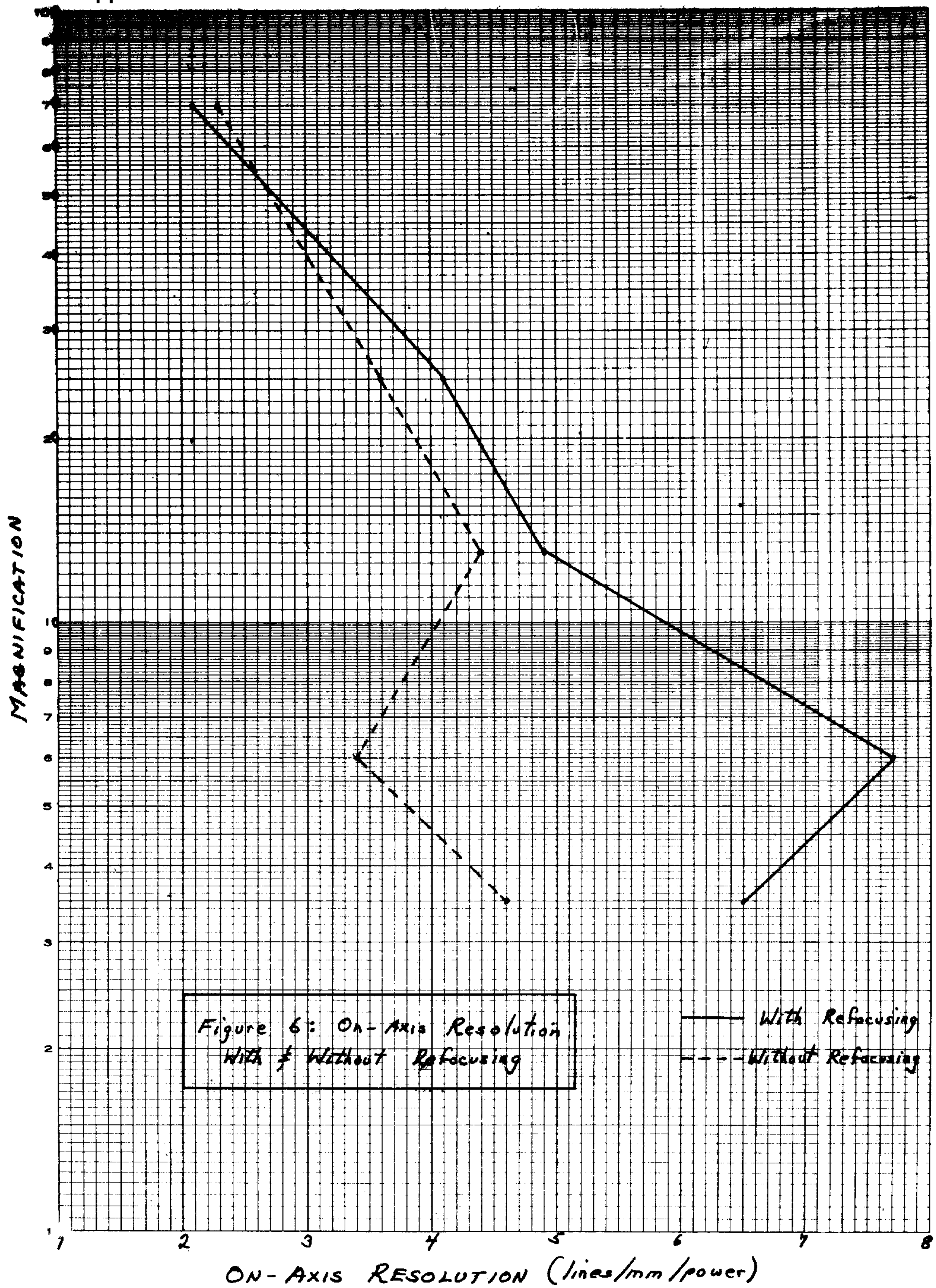

Figure 6: On-Axis Resolution With & Without Refocusing

were somewhat away from the edge). These measurements indicated a higher degree of distortion than either of the other two methods, with about 15% distortion near the edges of the screen and about 14% approximately midway between the center and the four corners of the screen.

c. Pincushion distortion is very noticeable at the lower magnifications. Although the degree of distortion, as measured in percent, is quite small, the amount of distortion seen on the screen is quite large. At 3.5x, a measurement was made of the displacement of a line which should have been horizontal across the top of the screen: in the top center of the screen, the line was displaced about 1 13/16" from the top of the screen. Aesthetically, this did not appear very well; however from the practical standpoint, this distortion would not seem to cause severe problems.

7. Image Position on the Optical Axis: It was found that any portion of the 9 1/2" width of the film could be viewed (positioned) at the center of the screen at all magnifications.

8. Field of View:

a. The problem of vignetting at low magnifications has been previously mentioned. It was found, while performing the field of view tests, that, if the magnification was reduced at a slow speed, the system would not drive to the lowest magnification: this resulted in 1.74" of the 9 1/2" film format not being displayed on the screen. If the magnification control was actuated at its higher speed settings, the system would "home" to the lowest magnification and the entire 9 1/2" diameter area would have been fully displayed if there were no vignetting.

b. The additional field of view test results are shown in Figure 7. It appears as if the field of view is adequate for the tasks for which the Model 100 will probably be used. In general, the field of view is about 845mm divided by the magnification.

9. Film Transport System:

a. The film transport system is generally well designed; however, a number of problems were noted during the tests. The system is servo-controlled, and as such it is subject to the problems inherent in that type of system. However, a series of "maximum performance" tests resulted in parting the film only once (at a splice).

b. The film speeds were measured for both the maximum and minimum at six magnifications: the results are shown in Figures 8 and 9. It is noted that the speed in the scan mode is a function of the magnification (slower speeds at higher magnification); however, this is not true for the slew mode. The film speeds in the two modes do not overlap (i.e., the minimum slew speed is from twice as fast as the maximum scan speed at 3.5X, to 59 times as fast at 82x). This is particularly

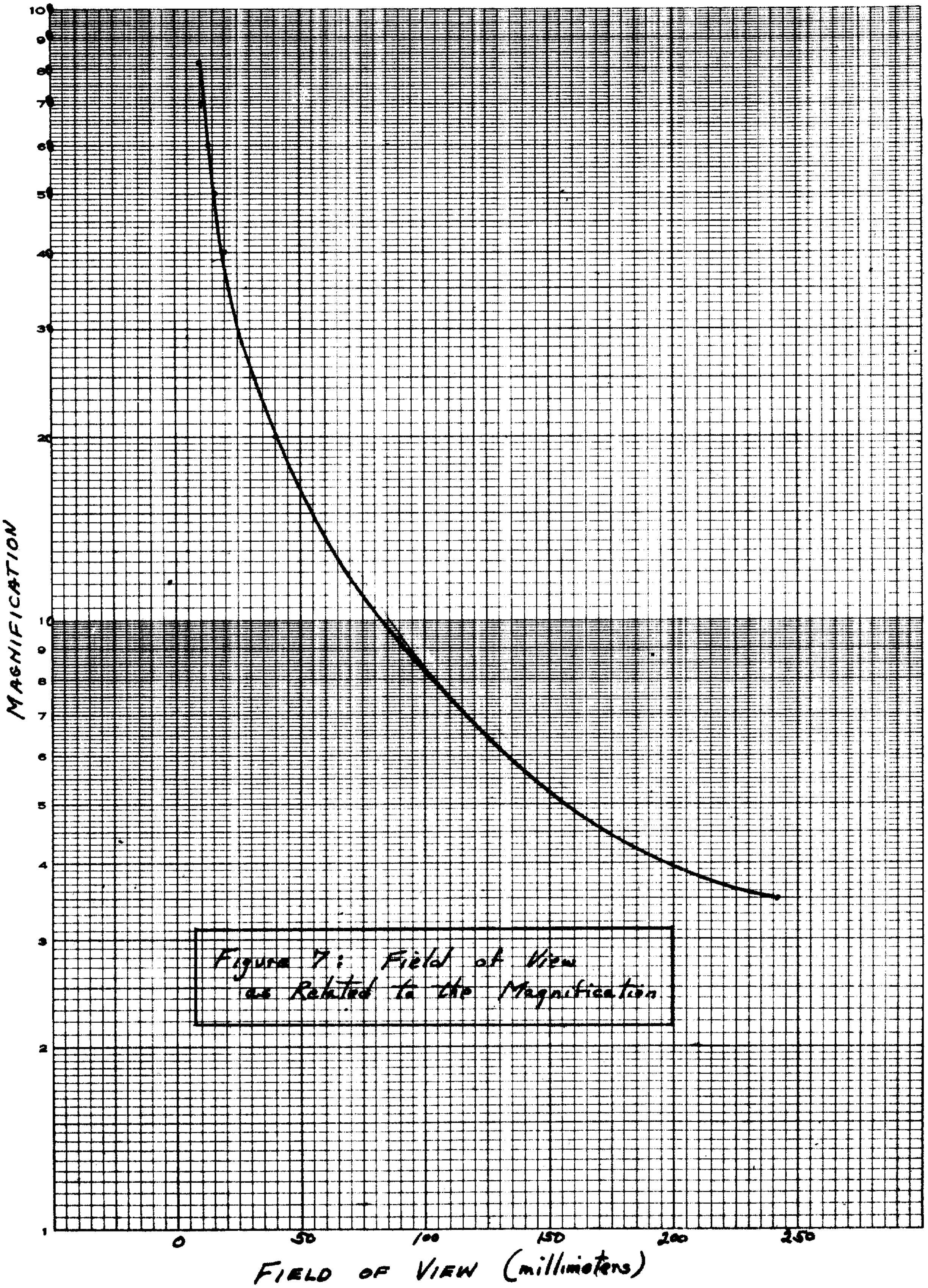

Figure 7: Field of View as Related to the Magnification

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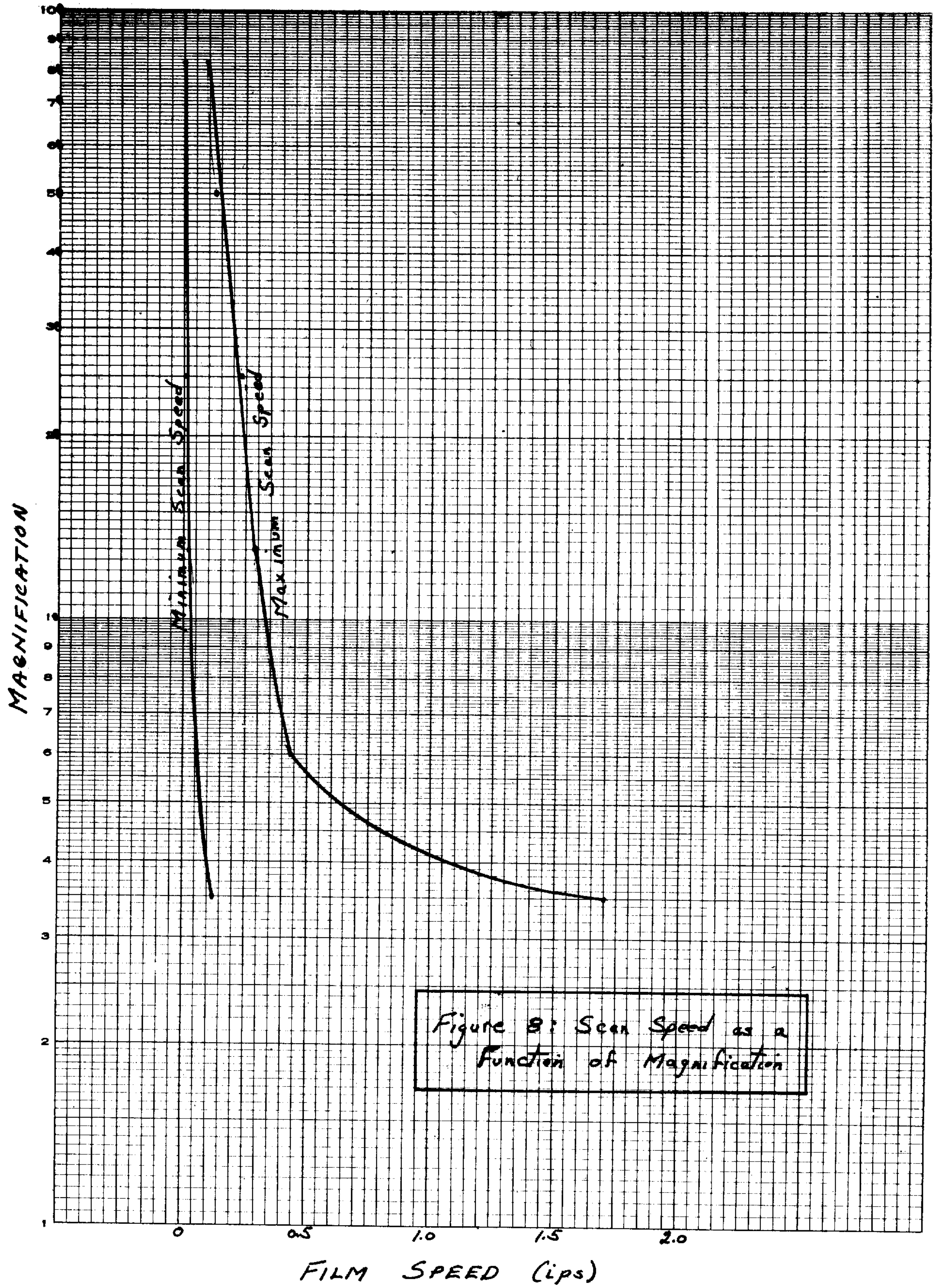
MAGNIFICATION
FILM SPEED (ips)
Minimum Scan Speed
Maximum Scan Speed
0
0.5
1.0
1.5
2.0
Figure 8: Scan Speed as a Function of Magnification

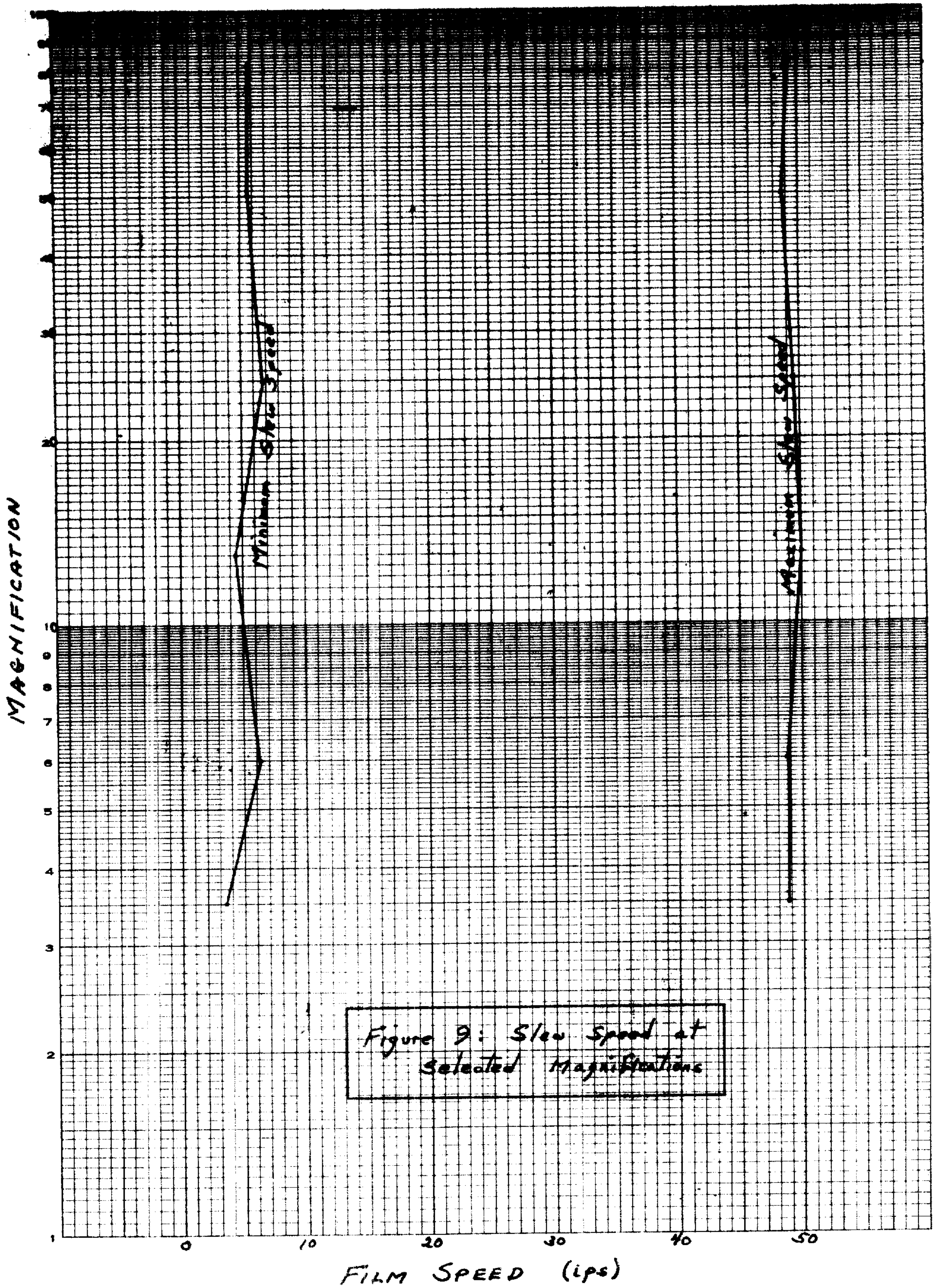

Figure 9: Slew Speed at Selected Magnifications

noticeable at the high magnifications where the maximum scan speed is too slow and the minimum slew speed is too fast.

c. The film speed control has been designed so that the smallest initial movement of the joystick causes the film platen to open, then an initial speed is imparted to the film (see Figure 10a). This causes some problems in control of the film in that the initiation of film movement is sudden; and if it is desired to move the film a very small distance, that distance is often exceeded. It would seem that a smoother approach would be to design the film speed control so that the slowest speed in the scan mode is closer to zero, and there is no sudden initial speed imparted to the film (see Figure 10b). Such a control has been successfully used on similar equipment.

d. The film drive system contains a high/low tension switch which must be properly set when the film is loaded. The high position is for 9 1/2" and 5" film, and the low position is for 70mm film. During the execution of the tests, there were several instances when the switch was not properly set and problems were encountered. In one case, film was torn when 70mm film was loaded with the switch in the high position. Since the clamps for the film reels must be moved to the appropriate reel size when the film is loaded, it would appear to be better to place a micro-switch in the 70mm reel clamp position. This switch would then be

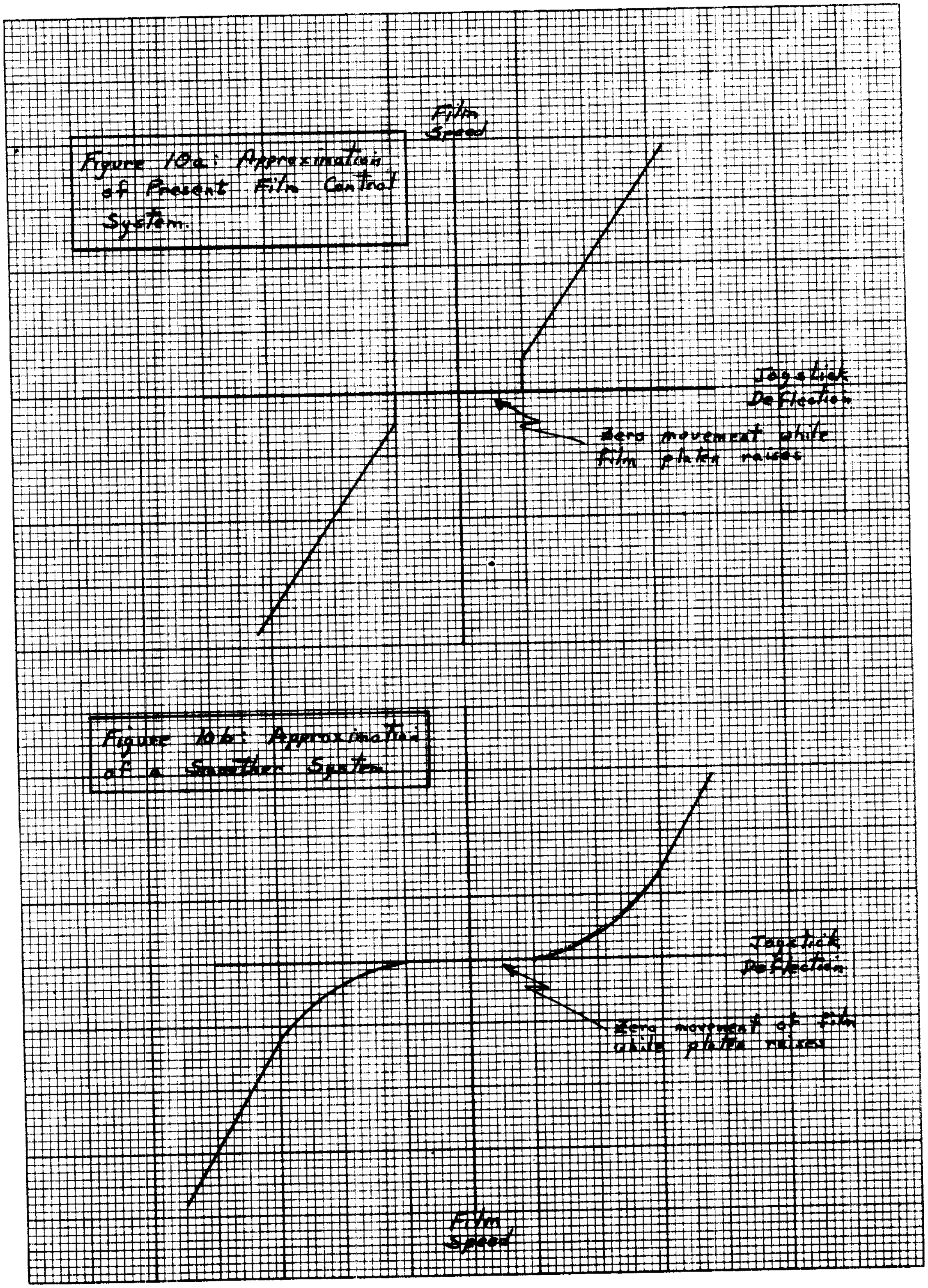

Figure 10a: Approximation of Present Film Control System.
Film Speed
Joystick Deflection
Zero movement while film plate raises
Figure 10b: Approximation of a Smoother System
Joystick Deflection
Zero movement of film while plate raises
Film Speed

actuated by loading a 70mm reel, and the film tension would be automatically adjusted for that size film (low tension).

e. It was found that film motion at the slowest speeds was not as smooth as on comparable equipment. In addition, it was noted that the film would snap taut when the joystick was released from a drive position in the slew mode (i.e., allowed to return to the center, or zero film speed, position by itself). This was particularly noticeable when the roll of 70mm film was in use, and the film finally parted at a splice. [redacted] personnel in- STAT formed the test team that this was caused by improper adjustment of the tension system for 70mm film. The system was then adjusted; however, experience throughout the remainder of the test showed that film slapping or snapping was generally not a problem.

f. The scratch test showed (by visual examination of the film at high magnification on the viewer screen) that the film transport system is essentially scratch free. Some minor scratching was noted at the edge of the roll of film: this was determined to have been caused by the film diameter sensor arm which has a nylon roller in contact with the film.

g. At the same time that the scratch test was run, the accuracy of the film footage counter was checked. Approximately eight feet of error was obtained over a measured film length of 50 feet. This is an error of

16%, and it is considered to be unsatisfactory for operational use. (Generally, an accuracy of 1% is specified for film footage counters on RADC developmental photo interpretation equipment.)

h. It was noted that the film drive joystick could be deflected beyond the maximum speed range of the film drive system. Since this caused the speed control to effectively disengage, the film drive stopped upon maximum joystick deflection. The joystick should be adjusted or modified so that maximum deflection will provide maximum film drive speed.

i. Film loading and unloading is generally much easier and faster on the Model 100 than on comparable equipment presently in use. This is because the film is located just inside the front of the viewer, and the film path is uncomplicated. The film unloading procedure, however, requires the operator (once the film has been driven until it is stopped by the end-of-roll sensor) to first press the end-of-roll over-ride switch, and, while that is still being held down, pressing the rewind switch. A simpler approach would be to have the rewind switch accomplish the end-of-roll override function and, with one momentary actuation, cause the entire rewind function to take place no matter how much film is on the supply or take-up reels. In addition to this problem, it was noted that the film platen consists of a top glass which is optically ground, and which must be removed during film loading operations (but not during unloading). Since this glass is both expensive and fragile, some provision should be made to minimize handling by operator personnel.

10. Film Temperature:

a. The results of the film temperature test are shown in Figure 11. The dips in the film gate temperature curve indicate reductions in magnification, except for the final dip at 86 minutes when the lamp was turned off. It is noted that the ambient room temperature increased along with the film gate temperature. This was caused by the Model 100 being in a closed "room" (a portion of a large room--it was enclosed with heavy, black, floor-to-ceiling drapes). The cooling air for the viewer was obtained from outside the enclosure and pumped into the machine. The heated air from the viewer was vented to the room atmosphere, thereby causing the ambient temperature increase.

b. The maximum temperature differential between room ambient and the film gate was obtained 80 minutes after start of the test, with a difference of 25 degrees. Twenty-four degree differentials were obtained at 16 minutes and 55 minutes after test initiation (there was an equipment warm-up period of 31 minutes prior to turning on the lamp and starting the test). If the curve is extrapolated, it is indicated that both the film gate temperature and the ambient

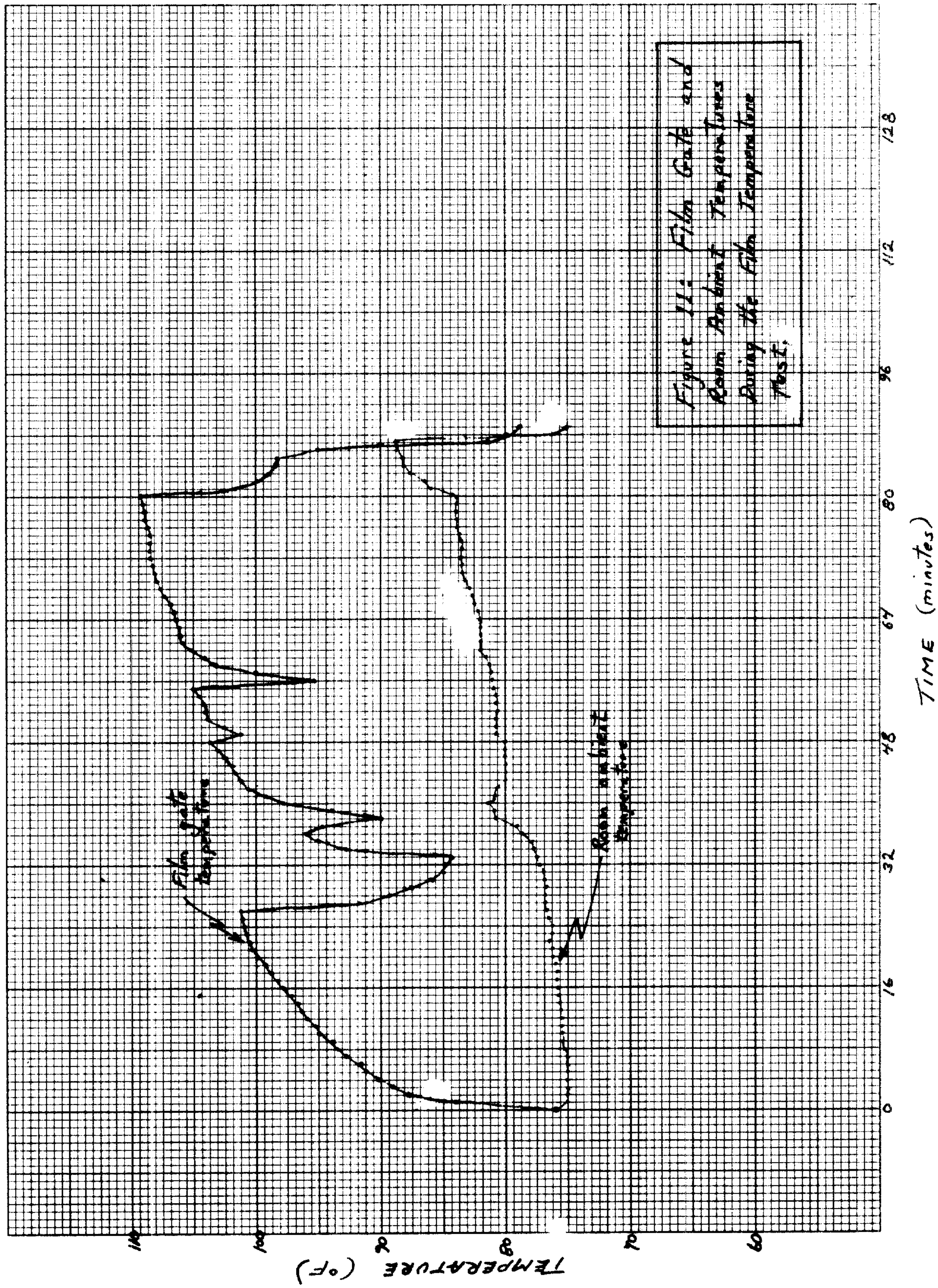

Figure 11: Film Gate and Room Ambient Temperatures During the Film Temperature Test.

room temperature would continue to rise if the test were continued. This could lead to film damage. Therefore, if the unit is to be used in an enclosed, non-air-conditioned room, cooling air should be drawn from outside the room and the exhaust air should be vented outside the room. If the unit is used in an air-conditioned facility, the cooling air can be drawn from within the room; however, the exhaust air should be vented outside to prevent an excessive load on the air conditioning system.

c. No film damage occurred during the film temperature tests. The maximum film gate temperature attained was 109°F at a room ambient temperature of 84°F.

11. Ease of Operation:

a. The Model 100 viewer was, in general, easy to operate. A number of the somewhat poorer aspects of rear projection viewers presently in use have been improved upon. The following aspects of the Model 100 are considered to be well thought out, useful, and of signficant advantage for efficient operation:

(1) The film is loaded in the front of the viewer.

(2) The projection lamp is located in the front of the viewer and is quickly changed.

(3) Maintenance access to the electronics and optics is by two large removable panels on each side of the viewer. Each panel is secured to the unit by eight

one-quarter-turn Dzus fasteners.

(4) The film drive control box, which includes the magnification, focus, and brightness controls, is on a cable and may be used six or eight feet away from the viewer. This is advantageous when other equipment is used adjacent to, and in conjunction with, the rear projection viewer. The operator need not move to the Model 100 to make minor changes in the projected image.

b. The following minor items made the viewer somewhat difficult to operate:

(1) The labels for the switches on the control box cannot be read in a room with reduced illumination.

(2) The "power," "end of reel," and "rewind" switches have such bright lights that when one of them is on it is difficult to read the film footage counter (the "power" switch indicator light is on continuously during viewer operation).

(3) The interlock switch which shuts the Model 100 off when the front door is opened can be placed in the interlock override position and inadvertently left there. This causes a problem if the door is subsequently opened and the system remains on. The override position of this switch should project toward the door so that when the door is closed the switch is automatically placed back into the normal interlock position.

(4) There is the danger, as previously mentioned, that the top glass for the film platen could be accidently dropped during film loading.

G. Conclusions:

STAT 1. The [redacted] Model 100 rear projection viewer represents a significant advance in the capability for detailed photo interpretation using a rear projection viewer. This advance is due to the ability to select the precise magnification desired by the operator, and the ability to accomplish interpretation at projected magnifications up to 82x.

STAT 2. The [redacted] Model 100 is approximately comparable in other capabilities to rear projection viewers presently in use.

STAT 3. The [redacted] Model 100 appears to be easier to maintain (preventive and corrective maintenance) than the rear projection viewers presently in use (no tests were made in this area).

STAT 4. The [redacted] Model 100 is-well constructed and will meet the rigors of use in Air Force fixed reconnaissance exploitation facility environments.

H. Recommendations:

1. It is recommended that one [redacted] Model 100 STAT
rear projection viewer be purchased by the Air Force and

subjected to an operational test and evaluation of at least six-months duration.

2. It is recommended that any additional procurement of [redacted] Model 100 viewers be delayed until the results of the operational test and evaluation are available.

STAT

3. It is recommended that, if any Model 100 viewers are purchased, they embody the following modifications:

a. Required:

(1) An increase in the open gate screen brightness to at least 250 foot-lamberts at the center of the screen at 3.3x (a goal of 400 to 500 foot-lamberts is suggested).

(2) A more precise control for the image rotation.

(3) A more accurate film footage counter.

(4) Overlapping film drive speeds between the scan and slew modes.

(5) A simpler film rewind procedure.

(6) Protection for the top glass on the film platen during film loading.

(7) Easily readable labels (possibly back lighted) for the film drive control box switches.

(8) Reduction of the intensity of the indicator lights for the "power," "end-of-reel," and "rewind" controls.

(9) An automatic-return interlock override switch for the front door.

b. Desirable (whether or not these are incorporated would depend on cost-effectiveness considerations):

(1) Reduction or elimination of the vignetting at low magnifications.

(2) Elimination of the Newton rings at low magnification.

(3) Reduction of the amount of distortion.

(4) Redesign of the film speed control to operate as shown in Figure 10b.

(5) Automatic change of the film tension when 70mm film is loaded.

4. It is recommended that the development of the

STAT

[redacted] Model 110 rear projection viewer be closely followed. This model, improved over the Model 100 in screen brightness and AWAR resolution, may be more suitable for Air Force operational use. However, it is not anticipated that the prototype Model 110 will be available for test before September 1968.

PRELIMINARY

TEST PLAN FOR NOD-100

SCREENING VIEWER

STAT

PURPOSE

The purpose of this test plan is to provide test procedures for checking the following Viewer performance functions:

1. RESOLUTION
2. SCREEN BRIGHTNESS
3. MAGNIFICATION RANGE
4. IMAGE ROTATION
5. FOCUS
6. DISTORTION
7. IMAGE POSITION ON OPTICAL AXIS
8. FIELD OF VIEW
9. FILM TRANSPORT SYSTEM
10. HUMAN FACTORS
11. FILM GATE TEMPERATURE

Test Facilities, Equipment & Materials

The following equipment and materials are required to perform the tests:

1. Power Source: 1 Ø, 115 V AC, 60 cps
2. Materials:
   a. 1000' roll of 70MM Film
   b. 250' roll of 5 inch test film, [redacted] STAT
      Test Film 35084A with calibration data)
   c. 1000' roll of 9 1/2 inch film.
   d. USAF Resolving Power Test Target, High Contrast
   e. USAF Resolution Conversion Chart
   f. Test Data Sheets, TABLES 1 thru 11 of this Document.
3. Support Equipment:
   a. Spectra Brightness Spot Meter, Model UB1/2 or equivalent.
   b. Spectra Power Supply or equivalent.
   c. Stop Watch
   d. Millimeter/Inch Ruler (12")
   e. Temperature recording (Thermo-Couple) device
   f. Volt Meter

Preparatory Procedures

Connect the Viewer to a 115 V AC power plug. Turn on and allow the system a short warm up period. Load the roll of 5 inch Test Film into the Viewer and start the testing procedure.

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1.0 Resolution Test

This test verifies the resolution capabilities of the viewer at various magnifications.

1.1 Position the USAF Resolving Power Test Target, which is spliced into the roll of 5" Test Film, onto the viewing screen.

Measure the resolution in the 9 positions shown on FIG. 1. Use the USAF Resolution Conversion Chart to convert the observed test patterns to lines per millimeter data and record the measurements (measured at 3.3X, 6X, 13X, 25X, 70X & Max.) in TABLE 1.

NOTES: Determine exact magnification by measuring the 0-1 pattern at the #1 position on the screen. Use a millimeter scale as direct readout of magnification, as a line pair of this pattern represents 1 millimeter.

Minor focus and/or illumination adjustments may be made after each magnification change to achieve optimum reading.

Measurements at random magnifications may be taken and must be recorded in TABLE 1.1.

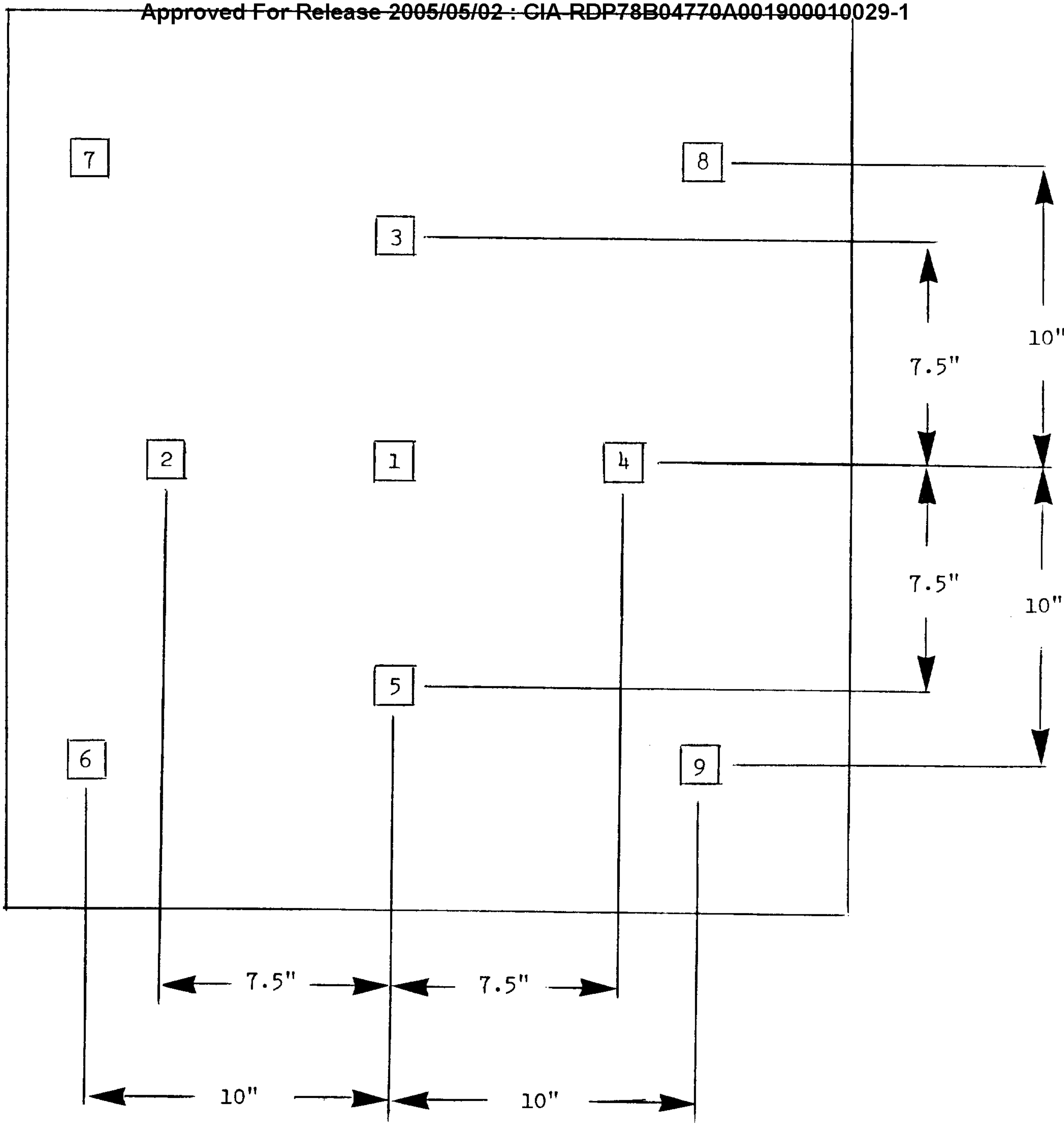

FIGURE 1
RESOLUTION PATTERN POSITIONS

ON PROJECTION SCREEN

2.0 Screen Brightness Test

This test verifies levels of screen illumination at various magnifications. Test is performed without film in the film gate, which has been thoroughly cleaned beforehand.

2.1 Position the Spectra Photometer or equivalent at a distance of 20 ± 1 inches and normal to the screen centerline (position #1 as shown in FIG. #2).

Adjust the brightness control to maximum. Record the meter data at 3.3X, 5X, 20X, 70X in TABLE 2. (Use control switch & panel indicator to set magnifications. Lamp Voltage shall not exceed 120 VAC).

Repeat measurements at positions #2 thru #9, as shown in FIG. #2, repositioning the photometer normal to each area and recording the read values in TABLE 2.

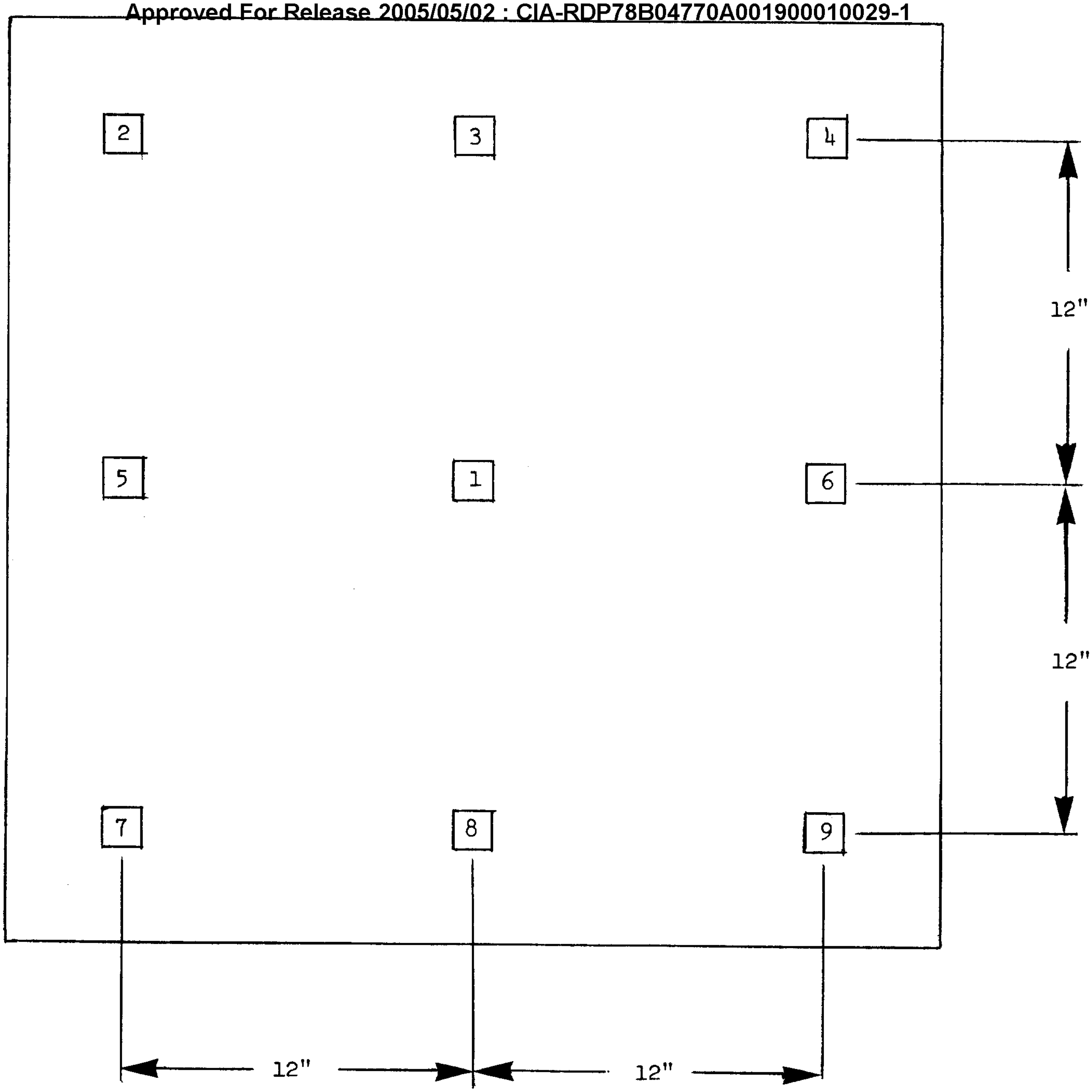

FIGURE 2
ILLUMINATION TEST POSITIONS
ON PROJECTION SCREEN

3.0 Magnification Range Test

This test verifies magnification range of the Viewer and the speed range of the magnification change.

3.1 Depress the "Mag" switch to cause the Zoom Lens drive to move to the lowest magnification.

Position the Resolution Test Target near the center of the viewing screen and measure, with a millimeter scale, one line-pair on the 0-1 (zero-one) pattern.

Record reading in TABLE 3; Low Magnification.

3.2 Drive the Zoom Lens to the upper LIMIT. Repeat measurement of the 0-1 target and record reading in TABLE 3; High Magnification

3.3 Turn the "MAG. SPEED SELECTOR" KNOB CCW to its limit.

Drive the zoom lens from high to low magnification (into the limit stop) and record the time in TABLE 3; Low Zoom Speed.

3.4 Turn the "MAG. SPEED SELECTOR" KNOB CW to its limit.

Drive the zoom lens from low to high magnification (into the limit stop) and record the time in TABLE 3; High Zoom Speed.

4.0 Image Rotation

This test verifies image rotation speed and position of the optical axis during rotation. Temporary cross hairs are required for this test and should be affixed on the screen.

4.1 Position a film frame with a cross hair target into the projection path (frame #4 or #5 of test film). Align the cross hair image with the one on the screen and rotate the image rotation control ring 90° from its position.

Record the time in TABLE 4.1. Rotate the control ring 180° from its position and record the time. Repeat the tests in both CW and CCW directions.

4.2 Align the cross hair image of the film with the one on the screen. Adjust the magnification until the 5" film fills the screen with edges of film touching top and bottom of the screen (6X).

Rotate the image control ring 180° from its position. Measure and record the optical axis displacement at the film plane in TABLE 4.2.

5.0 Focus Test

This test verifies the viewing systems ability to present the screen image in focus at any magnification setting.

5.1 Position the Resolving Power Target in the center of the screen. Drive the Zoom Lens to it's high limit position.

5.0 Focus

Adjust focus with the focus control switch.

Zoom down and stop to observe the clarity of image at 50X, 25X, 13X 6X, and 3.3X.

Record results in TABLE 5.1

6.0 Distortion

This test will determine distortion of the projection system at various magnifications.

6.1 Position Test Film Frame No. 15 in the center of the screen. Adjust magnification of 6X, verifying this by measuring the projected scale (each division = .05 inches).

Place the projected scale in position "A". Compute % distortion as follows:

$$100X \frac{(A - Y)}{Y} = \%\ \text{distortion}$$

where A = Measured projected scale image.

Y = Nominal scale, multiplied by magnification

Example: Assume a reading of 13.20 in the "A" position.

At 6X the nominal scale is 6 x 2.0 in = 12 in. then

$$100X \frac{(13.2 - 12)}{12} = 100X \frac{1.2}{12} = 10\%$$

Repeat computation of distortion at positions B and C.

Record in TABLE 6.

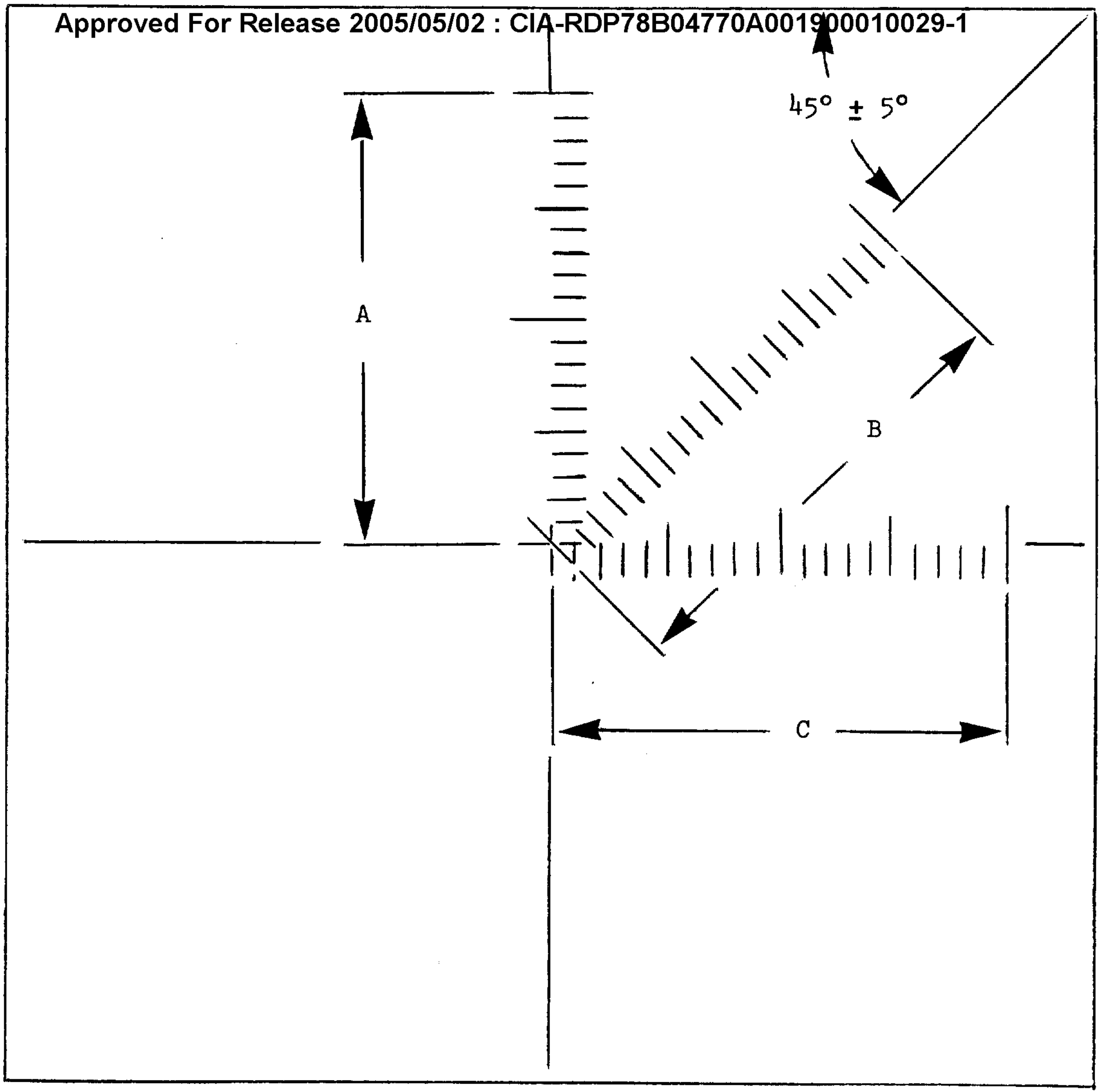

FIGURE 3

DISTORTION TEST POSITIONS

ON PROJECTION SCREEN

6.0 Distortion Continued

6.2 Adjust magnifications to 12X, 24X, 48X, and 70X and compute % distortion in each of the three positions.

7.0 Image Position on Optical Axis

This test verifies the ability to position on axis all portions of the format to the film center.

7.1 Load 9-1/2 inch film into the viewer. Adjust the magnification to its lowest range. Manipulating the Joystick Control, align the top edge of the film with the crosshair on the screen. Move the film in the opposite direction and align the bottom edge of film with the crosshair.

Select any point of the image and position this point at the crosshair on the screen using the Joystick control.

Record results in TABLE 7.

8.0 Field of View

This test verifies field of view of the projected image.

8.1 Position a 9-1/2 inch film frame on the viewing screen. Adjust the magnification to minimum value (3.3X).

Measure vignetted areas in the four corners of the screen and record the measured value in TABLE 8.1.

8.2 Increase magnification until the image fills the entire screen. Position the power resolving target in the center of the screen and measure the 0-1 pattern. Record the magnification in TABLE 8.2.

9.0 Film Transport System Test

The test verifies performance of the film transport system in the following areas:

a. Stability

b. Lack of film degradation

c. Speed ranges of film.

9.1 Stability

Using the 5" Test Film Roll perform the following tests: Advance film at various scan speeds in any direction desired. Observe film motion vs. response of the joystick control. The image on the screen should follow the deflected direction of the joystick, increasing speed with increased deflection.

The image should move smoothly without unusual jerkiness.

Record the observation in TABLE 9.1.

9.2 Lack of Degradation of Film

Operate film transport in "Scan" and "Slew" modes at minimum

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and maximum speeds. Make a number of sudden stops, releasing the joystick (automatic return to center). Observe for any unusual noises (other than edge scuffing on reel flanges), film tear or edge nicks, emulsion scratches, etc., and record findings in TABLE 9.2.

9.3 Film Speed Test

Position test film frame #3 at the viewing screen. Adjust magnification to 6X. Verify by measurement of projected scale on screen.

9.3.1 Minimum Scan Speed

Deflect the joystick until the image starts to move at the slowest rate possible. Start the stopwatch when the "0" graduation passes the crosshair on the screen. Stop the watch at the 6 inch graduation. Compute film speed as follows:

$$\frac{\text{Image speed/Magnification}}{\text{Time}} = \text{Film Speed}$$

Example: Assuming 20 seconds have elapsed to move image 6 inches at 6X magnification

then $\frac{6/6}{20} = .05$ in/sec.

Record computation in TABLE 9.3.1, "Min. Scan Speed".

9.3.2 Maximum Scan Speed

Repeat the Test, deflecting the joystick to the maximum, and, following the procedure above, compute and record "Max. Scan Speed" in TABLE 9.3.

9.3.3 Minimum Slew Speed

Depress "Slew Mode" button on the joystick and deflect fully to the right ("F" mark on the control ring). Hold until film stops moving ("END OF FILM" light will go on). Depress the "END OF FILM" button and retract approx. 20 feet of film. Depress "ZERO RESET" button on the footage counter.

Slowly deflect the joystick to the left ("R" mark on the control ring), moving the film at minimum possible speed. Release "ZERO RESET" button and simultaneously start the stop watch. Read the elapsed count on the footage counter after 12 seconds. Compute film speed in inches per second and record in TABLE 9.3.3.

Example: After 12 seconds, footage counter indicated 5 foot count.

then- $$\frac{5\text{ft} \times 12\text{in/ft}}{12\text{ sec}} = 5\text{ in/sec.}$$

9.3.4 High Slew Speed.

Repeat above procedure, this time deflecting the joystick to its max. position. Compute film speed and record in TABLE 9.3.4.

10.0 HUMAN FACTORS

This check verifies the human factors aspects of the viewer system in regard to operating ease, accessibility of functional controls and film transport for film loading and periodic maintenance.

10.1 Verify, by operating the viewer, ease of manipulation of all controls when seated in a standard, office-type swivel chair. Verify the ability of operating the viewer by either right or left handed person. Record findings in TABLE 10.1.

10.2 Depress the "REWIND" button on the control panel. The film shall automatically rewind onto the supply reel (RH) and the film advance stopped before completely leaving the take-up reel to prevent damage to the end of film. The film transport shall be automatically positioned with the reels facing front and the transport translated to the forward limit.

When the "END OF FILM" indicator lights up, depress the "REWIND" button. Rewind the remainder of the film by depressing and holding the "END OF FILM" button and deflecting the joystick towards "F" on the control ring. Record results in TABLE 10.2.

10.3 Open the front door. Unlatch the two quarter-turn locks on the Zoom Lens mirror housing and slowly raise the mirror to the"up" position. The mirror shall remain in the "up" position. Note the accessibility to the front glass element of the Zoom Lens, and the four screws, which mount the upper film platen. Verify and record in TABLE 10.3.

11.0 Film Plate Temperature Test

This test will verify max. film gate temperature reached in a 2 hour period and the damaging effects, if any, to the film.

11.1 Place a processed frame of film having an approx. density of ND-1.5 into the film gate.

Insert a temperature sensing, recording thermo-couple between the film platens in the center of optical system. Set the magnification control to high and the lamp brightness control to maximum and leave the system on for 2 hours.
(Lamp Voltage should not exceed 120 VAC).

Record the maximum temperature reached in TABLE 11.1.

11.2 Visually examine the film frame, first using the projection system, then physical observation after removal from the Viewer.

Record found damage, if any, in TABLE 11.2.

NOD-100 DATE:________________

Test BY:____________________ VERIFIED BY:__________

TABLE I

PROJECTION RESOLUTION TEST RESULTS

Item	Point	Mag.	Resol. L/MM	Comments	Item	Point	Mag.	Resol. L/MM	Comments
1	1	3.3X			26	8	13X		
2	2	"			27	9	"		
3	3	"			28	1	25X		
4	4	"			29	2	"		
5	5	"			30	3	"		
6	6	"			31	4	"		
7	7	"			32	5	"		
8	8	"			33	6	"		
9	9	"			34	7	"		
10	1	6X			35	8	"		
11	2	"			36	9	"		
12	3	"			37	1	70X		
13	4	"			38	2	"		
14	5	"			39	3	"		
15	6	"			40	4	"		
16	7	"			41	5	"		
17	8	"			42	6	"		
18	9	"			43	7	"		
19	1	13X			44	8	"		
20	2	"			45	9	"		
21	3	"			46				
22	4	"			47				
23	5	"			48				
24	6	"			49				
25	7	"			50				

NOD-100 VIEWER

DATE:___________________

TEST BY:____________________

VERIFIED BY:_____________

TABLE 2

SCREEN BRIGHTNESS TEST RESULTS

Item	Pos.	Mag.	Reading Ft/Lamb	Comments	Item	Pos.	Mag.	Reading Ft/Lamb	Comments
1	1	3.3X			21	6	3.3X		
2	1	5X			22	6	5X		
3	1	20X			23	6	20X		
4	1	70X			24	6	70X		
5	2	3.3X			25	7	3.3X		
6	2	5X			26	7	5X		
7	2	20X			27	7	20X		
8	2	70X			28	8	70X		
9	3	3.3X			29	8	3.3X		
10	3	5X			30	8	5X		
11	3	70X			31	8	20X		
12	3	70X			32	8	70X		
13	4	3.3X			33	9	3.3X		
14	4	5X			34	9	5X		
15	4	20X			35	9	20X		
16	4	70X			36	9	70X		
17	5	3.3X							
18	5	5X							
19	5	20X							
20	5	70X							

NOD-100 VIEWER   DATE: ________________

TEST BY: ____________________   VERIFIED BY: ____________________

TABLE 3

MAGNIFICATION TEST RESULTS

3.1 Low Magnification: X

3.2 High Magnification: X

3.3 Zoom Range Speed - Low - - - - sec.

3.4 Zoom Range Speed - High: _ _ _ sec.

TABLE 4

IMAGE ROTATION TEST RESULTS

4.1 Image Rotation Speed

90° image rotation - CW : _ _ _ Sec

90° image rotation - CCW: _ _ _ Sec

180° image rotation - CW : _ _ _ Sec

180° image rotation - CCW: _ _ _ Sec

4.2 Optical Axis Displacement

$\frac{\text{(Reading)}}{6}$ = _ _ _ _ inches.

NOD-100 VIEWER DATE__________________

TEST BY:______________________ VERIFIED BY: ___________

TABLE 5

FOCUS TEST

5.1 System Focus at:

Zooming Down

70X:____Yes____No

50X:____Yes____No

25X:____Yes____No

13X:____Yes____No

6X:____Yes____No

3.3X:____Yes____No

Comments:____

____

NOD-100 Viewer DATE: ______________

TEST BY: ______________ VERIFIED BY: ________

TABLE 6

DISTORTION TEST RECORD

6X	12X	24X	
____ %	____ %	____ %	(Vertical)
____ %	____ %	____ %	(45°)
____ %	____ %	____ %	(Horizontal)

48X	70X	
____ %	____ %	(Vertical
____ %	____ %	(45°)
____ %	____ %	(Horizontal)

TABLE 7

IMAGE POSITION ON OPTICAL AXIS

Can any part of 9-1/2 inch format be positioned at the center of the screen?

____ Yes ____ No

Comments ____

TABLE 8

FIELD OF VIEW TEST RECORD

8.1 Vignetting at each corner ______ in. at 3.3X

8.2 Full Screen image at: ___ X

NOD-100 Viewer DATE: ____________

TEST BY: ____________ VERIFIED BY: ____________

TABLE 9

FILM TRANSPORT SYSTEM TEST

9.1 Does the projected image:

a. Move smoothly in the direction of joystick deflection? _ _ _ _

b. Does speed increase with increase of joystick deflection? _ _ _ _

Comments: ____________

9.2 Does any part of the film show damage in form of:

a. Tears or nicked edges: _ _ _Yes _ _ _ No

b. Emulsion Damage: _ _ _Yes _ _ _ No

Comments: ____________

9.3.1 Min. Scan Speed: _ _ _ _ in/sec

9.3.2 Max. Scan Speed: _ _ _ _ in/sec

9.3.3 Min. Slew Speed: _ _ _ _ in/sec

9.3.4 Max. Scan Speed: _ _ _ _ in/sec

Comments: ____________

NOD-100 Viewer DATE: ______________

TEST BY: ____________________ VERIFIED BY: _________

TABLE 10

HUMAN FACTORS CHECK

10.1 Are controls easily reached and manipulated during operation?

_ _ _ _ Yes _ _ _ _ No

Can the Viewer be operated by either right or lefthanded persons?

_ _ _ _ Yes _ _ _ _ No

10.2 Does the Viewer perform the rewind cycle as described in 10.2?

_ _ _ _ Yes _ _ _ _ No

10.3 Are glass film platens, exposed lens elements and mirrors accessible for cleaning?

_ _ _ _ Yes _ _ _ _ No

TABLE 11

FILM TEMPERATURE TEST

11.1 Max. recorded film temperature: _ _ _ _ °F

11.2 Did the test film show any damage, such as burns or bubbles?

_ _ _ _ Yes _ _ _ _ No

Comments: ____

____

Appendix B

SUMMARY OF RESULTS

1. Resolution Test: The results of the resolution test are given in Tables B-2A and B-2B.

2. Screen Brightness Test:

Magnification	Brightness (foot-lamberts) Center	Average Edge	Eveness
3.3	83	46.4	4.25%
5	65	55.75	47.6%
20	30.5	21.1	57.2%
70	15	10.2	53.3%

3. Magnification Range Test:

Low Magnification: 3.5X

High Magnification: 82X

Time to zoom from 3.5X to 82X

low speed: 18 seconds

high speed: 3 seconds

TABLE B-1A: Measured Resolution

Magnification	Resolution (lines/mm/power)							
	AVERAGE AWAR		RADIAL AWAR	TANGENTIAL AWAR	ON-AXIS		AVERAGE EDGE	
	SAC	RADC	RADC	RADC	SAC	RADC	SAC	RADC
3.3	1.74	1.57	1.43	1.76	6.12	6.86	0.95	1.05
6	1.94	2.94	3.82	2.07	7.56	7.55	1.84	2.57
13	3.29	2.77	3.29	2.23	6.96	4.92	2.02	2.17
25	3.86	3.05	3.31	2.78	5.13	4.04	3.23	2.78
70	3.01	2.27	2.47	2.06	2.90	2.05	3.01	2.30

TABLE B-1B: RESOLUTION WITH 1000 LINES/MM TARGET

Magnification	Resolution (lines/mm/power)	
	Focusing	Without re-focusing
3.3	6.05	4.80
6*	3.33	3.33
13	4.86	4.86
25	4.00	4.00
50	3.17	2.50
70	2.85	2.27
82	3.06	----

*At this magnification, the block indicating a resolution of 8.56 lines per millimeter could be resolved; however the blocks between 3.33 and 8.56 lines/mm could not be resolved.

4. Image Rotation Test:

a. Speed of Rotation: 90° clockwise: 7.8 sec.

90° counter clockwise: 7.2 sec.

180° clockwise: 15.9 sec.

180° counterclockwise: 15.0 sec.

b. Optical Axis Displacement:

$\frac{6}{6}$ = 1 MM displacement

5. Focus Test: Generally in satisfactory focus throughout the magnification range.

Magnification	On-Axis Resolution (lines/mm/power)	
	With Focusing	Without Focusing
3.5	6.5	4.6
6	7.7	3.4
13	4.9	4.4
25	4.1	3.6
70	2.1	2.3

6. Distortion Test: The results of the distortion test are given on Table B-2.

25X1

TABLE B-2: MEASURED DISTORTION

Distortion (percent)

Magnification	[redacted] Method			Alternate Method		
	Vertical	45°	Horizontal	Vertical	45°	Horizontal
6X	1.57	1.40	1.30	1.10	1.25	1.05
12X	1.04	1.04	0.70	2.56	5.10	5.10
24X	1.65	1.28	1.56	2.24	2.57	2.54
48X	2.43	2.22	2.00	7.86	10.50	6.55
70X	4.24	4.46	4.02	6.24	7.95	5.38

Third Method (all at 15X magnification):

Position		Distortion (percent)
Upper Left	Edge	14.54
	Inside	15.8
Upper Right	Edge	14.17
	Inside	15.8
Lower Right	Edge	13.98
	Inside	15.8
Lower Left	Edge	14.17
	Inside	15.9
Top Center	Edge	15.63
Right Center	Edge	15.27
Bottom Center	Edge	15.63
Left Center	Edge	15.63

7. Image position on Optical Axis:

Any portion of the 9 1/2" format can be positioned in the center of the screen.

8. Field of View:

a. Vignetting (measured on a line radial to the optical axis and passing through the four corners of the screen):

Upper left: 6"

Upper right: 6"

Lower left: 5"

Lower right: 4"

b. Magnification to fill the entire screen with a 9 1/2" film frame: At the lowest magnification, the entire 9 1/2" format cannot be viewed (1.74" of the film is not displayed unless the magnification control is actuated at its highest speed from higher to lower magnification.

c. Test Target:

Approximate Magnification	Field of View
20	40MM
40	20MM
50	16MM
60	13+MM
70	10+MM
82	about 9.5MM

9. FILM SPEED:

Magnification / Mode	Speed (inches per second/on the film)					
	3.3	6	13	25	50	82
Minimum Scan	0.122	0.0522	0.0198	0.0073	0.0042	0.0044
Miximum Scan	1.70	0.439	0.288	0.214	0.125	0.098
Minimum Slew	3.4	6.2	4.4	6.8	5.7	5.8
Maximum Slew	48.8	48.8	50.0	49.4	48.7	49.2

10. Film Temperature (film gate):

a. After two hours with 1.5 density film at 70X magnification: 109° F, no damage.

b. After two hours with 2.0 density film at 70X magnification: no damage.

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13. ABSTRACT

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The [redacted] Model 100 rear projection viewer was tested to determine its specific capabilities. The tests accomplished included AWAR resolution, screen brightness, distortion, magnification, field of view, film transport speeds, and ease of operation. The results indicate that this viewer is comparable to similar viewers presently in use, but it has a significant additional capability of continuous zoom magnification from 3.5x to 82x.

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